# Bred vectors and forecast errors in the NASA coupled general circulation model

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***Abstract***

The breeding method has been implemented in the NASA Global Modeling and Assimilation Office (GMAO) coupled general circulation model (CGCM) in its operational configuration where ocean data assimilation is used to initialize the coupled forecasts. Bred vectors (BVs), designed to capture the dominant growing errors in the atmosphere-ocean coupled system, are applied as initial ensemble perturbations. We investigate the potential improvement for ensemble prediction by comparing BVs with the oceanic growing errors, estimated by the one-month forecast error from the non-perturbed forecast.

Our results show that one-month forecast errors and BVs from the NASA CGCM share very similar features: BVs are clearly related to forecast errors in both SST and equatorial subsurface temperature, particularly when the BV growth rate is large. Both the forecast errors and the BVs in the subsurface are dominated by large-scale structures near the thermocline. Our results suggest that the forecast errors are dominated by dynamically evolving structures related to the variations of the background anomalous state, and that their shapes can be captured by BVs, especially during the strong 1997-1998 El Niño. Hindcast experiments starting from January 1997 with one pair of BVs achieve a significant improvement compared to the control (unperturbed) hindcast by capturing many important features of this event, including the westerly wind burst in early 1997.

***Popular Summary***

The El Niño-Southern Oscillation (ENSO) phenomenon rooted from the tropical Pacific has an important impact on global scale. Currently, the state-of-art numerical model, like the NASA GMAO coupled global circulation model (CGCM), is able to capture many essential features of ENSO. And, the ensemble forecasting system is designed to predict more probable evolutions of the atmospheric/oceanic state by perturbing the initial conditions of the CGCM. However, the skill of ENSO prediction is limited and depends on the initialized seasons. We believe that the ensemble forecasting system of the current operational CGCM is not optimal and may give us room to improve the prediction skill.

In this study, the breeding method is implemented in the NASA operational CGCM and used to generate the atmosphere-ocean coupled perturbations related to slowly-varying ENSO instability. We compare the structure of these bred perturbations with the forecast errors obtained from the same CGCM and examine their relationship to the evolution of the ENSO events in order to understand their potential to correct the errors. Also, we evaluate the impact of using such perturbations to predict the 1997-98 El-Niño event.